Irrigation Formulas and Conversions

Danny H. Rogers
Extension Irrigation Engineer

Mahub Alam
Extension Irrigation Specialist

Water Measurement

1 cubic foot = 7.48 gallons = 62.4 pounds of water
1 acre-foot = 43,560 cubic feet = 325,851 gallons = 12 acre-inches
1 acre-foot covers 1 acre of land 1 foot deep; 1 acre-inch = 27,154
1 cubic meter = 1,000 liters = 264.18 gallons
1 acre-inch = 450 gallons per minute (GPM) or 1 cubic foot per second (cfs)
1 gallon = 128 ounces = 3,785 milliliters
1 pound = 454 grams

Pressure

1 pound per square inch (psi) = 2.31 feet of water
A column of water 2.31 feet deep exerts a pressure of 1 psi
feet of head = psi x 2.31
Total Dynamic Head (TDH) includes: Pumping Lift, Elevation Change, Friction Loss, and Irrigation System Operating Pressure
TDH = Lift + Elevation + Friction + System Pressure

Area/Length

1 acre = 0.405 hectare (ha) = 43,560 feet²
1 inch = 2.54 centimeters

Horsepower

Water Horsepower (WHP) — power required to lift a given quantity of water against a given total dynamic head.

WHP = \( \frac{Q \times H}{3,960} \) where: Q = flow rate, GPM
H = total dynamic head, feet

Brake horsepower (BHP) — required power input at the pump.

BHP = \( \frac{WHP}{E} \) where: E = pump efficiency

Power Unit Horsepower

Electric Units: approximate name plate horsepower = \( \frac{BHP}{0.9} \)

Internal combustion units:

Must derate 20% for continuous duty
5% for right-angle drive
3% for each 1,000 feet above sea level
1% for each 10° above 60°F

Approximate Engine Horsepower Required = \( \frac{BHP}{0.80 \times 0.95 \times 0.91 \times 0.96} \) cont. drive 3,000' 100°F
duty elevation
Nebraska Performance Criteria (NPC)

**Energy source** | WHp-hours per unit of fuel
--- | ---
Diesel | 12.5 WHp-hrs per gallon
Propane | 6.89 WHp-hrs per gallon
Natural gas:
925 BTU/ft³ | 61.7 WHp-hrs per 1,000 ft³ (MCF)
1,000 BTU/ft³ | 66.7 WHp-hrs per 1,000 ft³ (MCF)
Electric | 0.885 WHp-hrs per kilowatt-hour

**Water Application**

Average Application (inches) = \( \frac{QT}{A} \)

where:
- \( Q \) = Flow Rate, Acre-Inches/Hour or GPM/450
- \( T \) = Length of Application, Hours
- \( A \) = Area Irrigated, Acres

Set Size (Acres) is computed by the formula:

\[ \text{No. of Rows} \times \text{Width of Row (Feet)} \times \text{Length of Run (Feet)} \]

\[ = \frac{43,560 \text{ Feet}^2}{\text{Acre}} \]

**Approximate Acreage Covered by Center Pivot**

Acres Covered = \( (\text{Radius of wetted area, feet})^2 \times 3.14 \)

\[ = \frac{43,560}{\text{Feet}^2/\text{Acre}} \]

For radius:
- Without end guns — add 40 feet to length of machine
- With end guns — add 75 feet to length of machine

**Irrigation Delivery Rate* per Acre (gpm/acre)**

<table>
<thead>
<tr>
<th>Net irrigation application (inches/day)</th>
<th>50</th>
<th>60</th>
<th>70</th>
<th>80</th>
<th>90</th>
<th>100</th>
</tr>
</thead>
<tbody>
<tr>
<td>******************************************</td>
<td>----</td>
<td>----</td>
<td>----</td>
<td>----</td>
<td>----</td>
<td>----</td>
</tr>
<tr>
<td>0.10</td>
<td>3.77</td>
<td>3.14</td>
<td>2.69</td>
<td>2.36</td>
<td>2.10</td>
<td>1.89</td>
</tr>
<tr>
<td>0.15</td>
<td>5.66</td>
<td>4.71</td>
<td>4.04</td>
<td>3.54</td>
<td>3.14</td>
<td>2.83</td>
</tr>
<tr>
<td>0.20</td>
<td>7.54</td>
<td>6.29</td>
<td>5.39</td>
<td>4.71</td>
<td>4.19</td>
<td>3.77</td>
</tr>
<tr>
<td>0.25</td>
<td>9.43</td>
<td>7.86</td>
<td>6.73</td>
<td>5.89</td>
<td>5.24</td>
<td>4.71</td>
</tr>
<tr>
<td>0.30</td>
<td>11.31</td>
<td>9.43</td>
<td>8.08</td>
<td>7.07</td>
<td>6.29</td>
<td>5.66</td>
</tr>
<tr>
<td>0.35</td>
<td>13.20</td>
<td>11.00</td>
<td>9.43</td>
<td>8.25</td>
<td>7.33</td>
<td>6.60</td>
</tr>
<tr>
<td>0.40</td>
<td>15.09</td>
<td>12.57</td>
<td>10.78</td>
<td>9.43</td>
<td>8.38</td>
<td>7.54</td>
</tr>
<tr>
<td>0.45</td>
<td>16.97</td>
<td>14.14</td>
<td>12.12</td>
<td>10.61</td>
<td>9.43</td>
<td>8.49</td>
</tr>
<tr>
<td>0.50</td>
<td>18.86</td>
<td>15.71</td>
<td>13.47</td>
<td>11.79</td>
<td>10.48</td>
<td>9.43</td>
</tr>
</tbody>
</table>

**Field delivery rate** = gpm/acre x acres irrigated

**Net irrigation** = gross irrigation x system efficiency

**Maximum Economical Pipe-flow Capacities**

A rule of thumb for coupled and gated pipe:

- 6 inches: 400 gpm
- 8 inches: 800 gpm
- 10 inches: 1,200 gpm